

Viking Mission Support

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DSN Network Operations

This report covers the relatively quiet Viking On Board Science & Telemetry period from November 15, 1976, through December 31, 1976, when Mars and the Viking spacecraft were in the Solar conjunction period. The period therefore presented the Viking Radio Science Team with a unique opportunity to utilize the DSN and Viking spacecraft to exercise their experiments with nonstandard station configurations, without the usual command and telemetry constraints.

I. Viking Operation Activities

The beginning of this reporting period (November 16, 1976) was coincident with the start of the Viking Extended Mission (VEM). At that time the Sun-Earth-Probe (SEP) angle was approximately 2.8 deg (from the center of the Sun's disc) and the degradation of the RF link caused by the proximity of the signal to the Sun was much that the Viking Orbiters were switched to a single subcarrier mode transmitting engineering telemetry only. The bit error rate was estimated at 23 in 4687 bits or 5×10^{-3} .

The 64-meter stations were using 100 kW of uplink power at this time on a daily basis to decrease the noise on the two-way doppler and ranging. The degradation of the RF links gradually increased as the SEP angle decreased, until the closed loop receivers were out of lock more than 50% of the time. Following is a summary of the events during the roughly symmetrical degradation and then improvement of the RF links through the solar conjunction period (see Figs. 1-3).

- Nov. 16 DSS 61, bit error rate about 5×10^{-3} . The Sun-Earth-Probe angle (SEP) was about 2.8 deg, and decreasing 0.3 deg/day.
- Nov. 18 DSS 61, bit error rate about 10^{-2} .
- Nov. 22 X-band practically out of lock all the time, especially in two-way (when uplink at S-band is perturbed by Sun). SEP about 1 deg.
- Nov. 23 DSS 14 could not lock closed-loop S-band receiver (about 50% out of lock) and could not lock telemetry on today's pass, beginning about 15:00 GMT (Day 76/328).
- Nov. 25 Minimum SEP occurred today (Day 76/330/00:00 approximately).
- Nov. 26 DSS 14 locked telemetry data (8-1/3 bps single subcarrier) on today's pass, beginning about 15:00 GMT (Day 76/331). Station also locked X-band downlink.

- Dec. 1 DSS 61 was first 26-meter downlink since minimum SEP. SNR about 2.5 dB, BER not available, but data was readable.
- Dec. 2 DSS 61 BER about 10^{-2} , data quality described as "very poor."
- Dec. 8 First 33-1/3 bps single subcarrier (obtained at both DSS 42 and DSS 43, with even DSS 42 SNR above threshold. SNR about 7.5 dB at DSS 43, BER not available).
- Dec. 13 SEP 5 deg today. First 2-kbps dual subcarrier (DSS 43).
- Dec. 14 First 4-kbps playback, DSS 14, SNR 5 dB (above threshold).
- Dec. 17 First 8-kbps playback, DSS 43, SNR 4 dB (above VIS threshold).

II. Viking Radio Science

Although during the solar conjunction period the Viking Orbiter and Lander uplink and downlink subcarrier data was virtually "lost in the noise," this gave the radio science team a unique opportunity to gather radio science data without the usual constraints of the normal mission operations. The radio science experiments detailed in the previous report were carried out as planned and results were as predicted or better. Following are some of the initial results of the radio science activities produced to date.

A. General Relativity Experiment

The Viking Flight Team and DSN completed the most stringent test of Einstein's General Theory of Relativity to date. A 0.5% accurate test of the relativistic time delay (Fig. 4) has already been accomplished, and it is expected that the test will achieve a 0.1% accuracy when all the lander ranging data is calibrated for solar corona effects and when sufficient long-term lander ranging and near-simultaneous orbiter ranging are obtained to correct for planetary ephemerides errors. The lander and near-simultaneous orbiter ranging will also be used as a dynamic test of the General Theory of Relativity as data is collected over the lifetime of the landers and orbiters.

B. Solar Corona Experiment

Extensive open-loop receiver analog and digital recordings were made by the DSN for the radio science solar corona experimenters at Stanford and JPL during the solar conjunction time period. X-band signals were observed and recorded within one solar radius on both entry and exit. Recordings were made when the signal passed through the chromosphere, but it has not been determined yet if any signal was detected.

In any case, this is probably the deepest penetration of the solar corona by any man-made signal.

On December 29/30, 1976, a very complex set of simultaneous solar corona observations were made. DSS 14 received and recorded open-loop S-band signals from VO-1 and VO-2 and closed-loop doppler from VL-1. Simultaneously, DSS 43 received and recorded open-loop S and X-band signals from VO-1, and DSS 42 received closed-loop doppler from VO-2. These multiple-spacecraft/multiple-station solar corona observations were made during the same passes that two very successful lander and near-simultaneous orbiter ranging passes were accomplished.

C. Lander Ranging

The lander and near-simultaneous orbiter ranging are also used for various Martian planetology experiments. Preliminary results from these experiments have been published in two *Science* articles.

Preliminary results for lander locations, radii at the landing sites, the orientation of the spin axis of Mars, and the spin rate of Mars have been published (*Science* 193, 803 (1976) and 194, 1337 (1976)). Extended mission lander and simultaneous orbiter tracking data are needed to improve the accuracy of these results and, specifically, to attempt to determine spin axis precession and nutation. Spin axis motion constants, combined with low-degree gravity field parameters, would provide data for determination of constraints and models for mass and density distributions in the interior of Mars, with applications to its origin and history.

Preliminary results are available for pressure and temperature profiles in the lower atmosphere, and for radii at occultation points, for about two-thirds of the occultations observed during the primary mission (summarized in *Science* 194, 1337 (1976)). The uncertainties are somewhat larger than for previous occultation measurements because of the noise introduced by the signals passing close to the Sun. Additional and more accurate occultation data will be obtained for VO-2 starting in about 2 weeks, and for VO-1 starting in April.

D. Orbiter Doppler

Orbiter S and X-band doppler will continue to be collected and processed for the Martian gravity field experiments. Both a global gravity field analysis and a local gravity field analysis will be done. The global gravity field solutions are based on full orbits of tracking data, and the local gravity field analysis is based on the S-band/X-band doppler near periapsis.

E. Earth Occultation

The earth occultation resumed on January 14 (as planned), but unfortunately only a small percentage of the occultations will yield useful data. This is due to the limited DSN tracking coverage available and the conflicting project requirements for the limited resources available.

F. Very Long Baseline Interferometer (VLBI)

Orbiter/quasar VLBI observations will resume on February 8 and 10. However, these observations will also be limited during the Viking Extended Mission due to limited resources, particularly DSN station coverage.

III. DSN Support for Viking

The statistics listing the DSN tracking support for Viking during this reporting period are listed in Table 1. The Discrepancy Report status for this period is summarized in Table 2.

IV. DSN Major Items

Two major items related to DSN Viking support were the ball and socket bearing rework at DSS 63 and the implementation of the MK III data subsystems at DSS 12.

A. DSS 63 Support

During the solar conjunction period the scheduled rework on the DSS 63 64-meter antenna was carried out as planned. Tests during 1976 had indicated that the three 32-in.-diameter truncated steel balls, which support the entire antenna structure, had become more difficult to move in their sockets, to the point where new lubricant could no longer be forced between the ball and socket bearing surfaces. The rework, which consisted of removing the three assemblies and fitting new ball and socket assemblies, was started on November 15, 1976, and successfully completed on December 14, 1976. Examination after removal showed that the original lubricant had dried and compacted, preventing injection of fresh lubricant, and that the ball units were "out of round." A similar rework is scheduled to take place at DSS 43 during March 1977.

B. DSS 12 Support

The MK III Data Subsystem (MDS) update of the entire DSN involves the sequential modification of all Deep Space Stations, starting with DSS 12 in October 1976 and finishing with DSS 11 in early 1978. The System Performance Tests planned for the 26-meter stations include all the Viking requirements and were successfully completed at DSS 12 in December 1976. Two Operational Verification Tests, one System Integration Test with the VMCCC, and one Demonstration Pass with the Viking Orbiter spacecraft are scheduled for January 1977. These tests will be repeated with DSS 62 and DSS 44 during February and March 1977.

Acknowledgment

J. P. Brenkle and William H. Michael, Jr., contributed inputs from the Viking Radio Science Team.

Table 1. DSN tracking support for Viking

November 16-30			
DSS	Number tracks	Hours tracked	Commands
11	3	11:18	0
12	—	—	—
14	32	179:16	0
42	2	16:14	0
43	24	143:14	0
44	—	—	—
61	8	44:20	0
62	—	—	—
63	—	—	—
Total	69	349:22	0

December			
11	19	120:32	419
12	—	—	—
14	59	356:26	2113
42	27	278:17	3
43	63	608:41	1514
44	—	—	—
61	42	297:56	308
62	—	—	—
63	30	215:14	262
Total	240	1877:06	4699

**Table 2. DSN Discrepancy Report status
November - December 1976**

DRs open	=	56 as of November 15, 1976
New DRs opened	=	98
DRs closed	=	102
DRs open	=	52 as of January 1, 1977

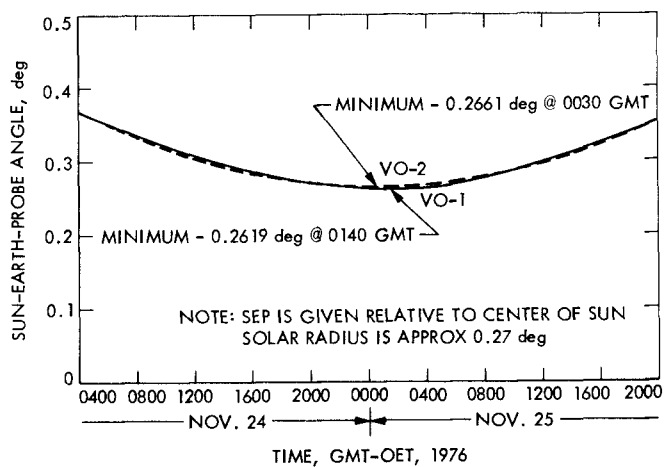


Fig. 1. Sun-Earth-Probe angle, November 24/25, 1976

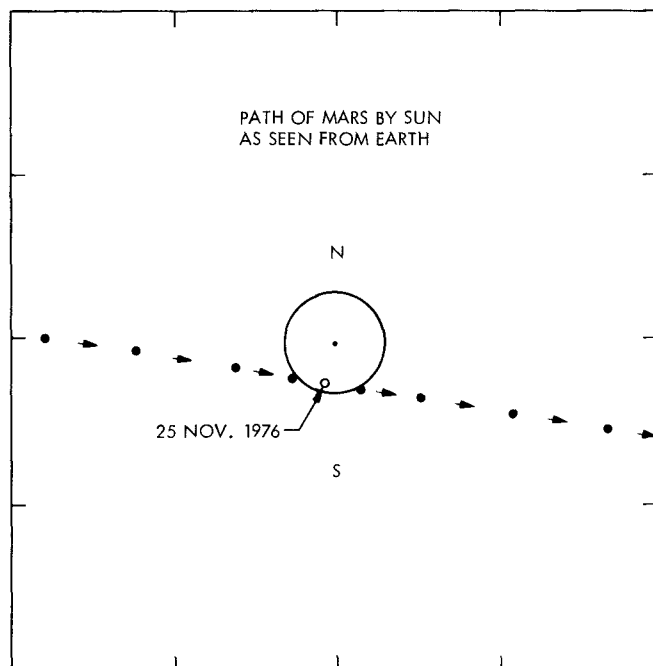


Fig. 3. Geometry of superior conjunction (Sun equator coordinate system)

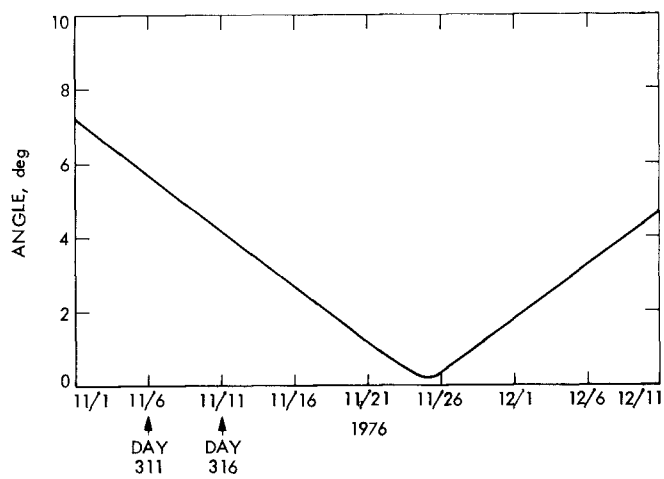


Fig. 2. Mars-Earth-Sun angle

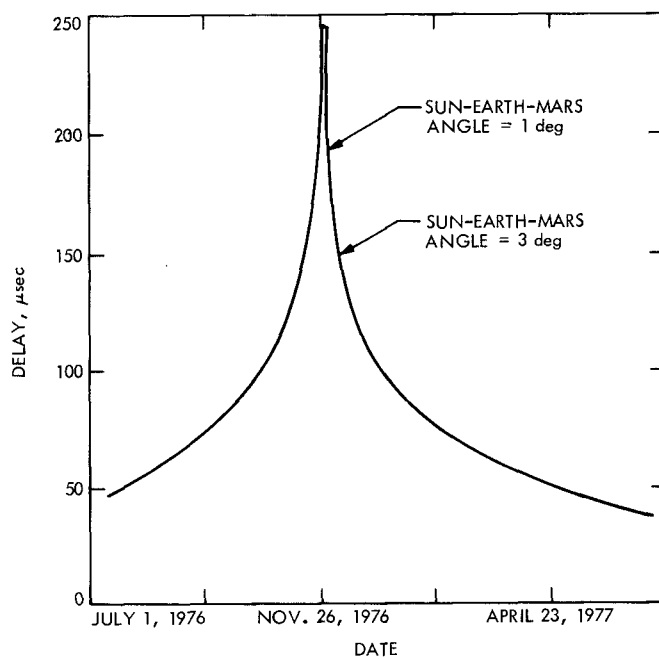


Fig. 4. Relativistic delay predicted for Viking